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Development of the F-22 Canopy Container, CNU-692/E

AFMC LSO/LOP
AIR FORCE PACKAGING TECHNOLOGY & ENGINEERING FACILITY
WRIGHT PATTERSON AFB, OH 45433-5540
27 February 2008

NOTICE

AFPTEF PROJECT NO. 06-P-112
TITLE: Development of the F-22 Canopy Container

ABSTRACT

The Air Force Packaging Technology Engineering Facility (AFPTEF) was tasked with the design of a new shipping and storage container for the F-22 Canopy in August of 2006. The new container is designed to replace the wood crate currently used.
The current container provides minimal shock protection and no environmental protection against corrosion. Additionally, the wood crate is bulky and very difficult to maneuver. AFPTEF used proven design techniques to meet these design requirements. The CNU-692/E, designed to SAE ARP1967A, is an aluminum, long-life, controlled breathing, reusable shipping and storage container. The new container protects the Canopy mechanically and environmentally. The container passed all qualification tests per ASTM D4169.
The CNU-692/E container not only meets user requirements but also provides an economic saving for the Air Force. The savings will be thousands of dollars per Canopy over the twenty-year life span of the container.

Total man-hours: 1296

PROJECT ENGINEER:

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INTRODUCTION

BACKGROUND – F-22 program office personnel at Wright-Patterson AFB contacted AFPTEF to request the design of a reusable container for the F-22 Canopy that would eliminate current shipping and storage risks. The Canopy is currently shipped in a wood crate. The crate does not have environmental controls and is not sealed by the nature of its construction. These two factors allow the container to "breathe" with continuously changing environmental conditions. There is no means to control breathing or remove the excess moisture that results, which could cause a corrosion problem on the Canopy. The crate also lacks any shock protection and allows for metal to metal contact between the Canopy and the crate mounts. The crate is also not compatible with one of the two approved lifting slings. The current packaging cannot be stored outside.

REQUIREMENTS – AFPTEF, Program Office personnel and Lockheed-Martin Aeronautics agreed upon a list of requirements during initial design discussions. Many of these requirements were not met by the wood crate. The requirements are as follows:

- Sealed/controlled-breathing container that protects against varied environmental conditions and weather during either inside or outside shipping and storage
- Canopy shock/vibration limited to 50 Gs
- Reusable and designed for long life (20 years)
- Low maintenance
- Field repairable hardware
- 4-way Forklift capabilities
- No loose packing material
- Compatibility with support equipment (Lifting Slings)

DEVELOPMENT

DESIGN – The F-22 Canopy Shipping and Storage Container (CNU-692/E) design meets all the users' requirements. The CNU-692/E is a sealed, welded aluminum, controlled breathing, reusable container (Appendix 2, Figure 1). The container is engineered for the physical and environmental protection of the Canopy during worldwide transportation and storage. The container consists of a base, cradle, and completely removable cover equipped with the special features listed below. Guide posts (Appendix 2, Figure 3) keep the cover from coming in contact with the Canopy during cover removal and replacement. The base is a one piece skid/double walled base extrusion with 4-way enclosed forklift openings, humidity indicator, pressure equalizing valves (1.5 psi pressure/ 1.5 psi vacuum), internal & external document holders and a desiccant port for easy replacement of desiccant (controls dehumidification). A silicone rubber gasket and quick release cam-over-center latches create a water/air-tight seal at the base-cover interface. Container external dimensions are 148.4 inches length, 58.5 inches width, and 51.3 inches height. Container empty weight is 1321 pounds, and 1721 pounds with the Canopy in place.

An aluminum cradle system is integrated into the base and suspended on six stainless steel helical wire rope isolators that provide shock and vibration protection to 50 G's (Appendix 2, Figures 2 & 3). The F-22 Canopy is attached to the cradle system by sliding the aft end of the canopy onto the aluminum rod held in place by three sleeve bearings. The brass wing nuts and aluminum knobs are loosened to release the swivel lock so it can be rotated into place. Tightening the knobs and wing nuts secure this end (Appendix 2, Figure 4). The Canopy is then lowered to rest on the two UHMW polyethylene mounts at the opposite end of the cradle (Appendix 2, Figure 5). The draw latches are looped over the Canopy pins, closed, and locked with quick pins (Appendix 2, Figure 6). There are no detachable parts on the container other than the container lid, which eliminates FOD risks.

REAPER ENGINE CONTAINER FEATURES	
Pressure Equalizing Valve	2
Humidity Indicator	1
Desiccant Port	1
Internal Document Receptacle	1
External Document Receptacle	1
Forkliftable (4-Way)	Yes
Cover Latches	24
Cover Lift Handles	None
Cover Lift Rings	4
Cover Tether Rings	None
Base Tie-down Rings	4
Stacking Capability	Yes

PROTOTYPE – AFPTEF fabricated one CNU-692/E prototype container in house for testing. The prototype container was fabricated in accordance with (IAW) all requirements and tolerances of the container drawing package. The drawing package used for prototype fabrication has been released for the manufacture of production quantities of the container. Each face of the container was uniquely identified for testing identification as shown below.

DESIGNATED SIDE	CONTAINER FEATURE
Top	Cover Top
Aft	Desiccant Port
Right	Right Side from Aft
Left	Left Side from Aft
Forward	Opposite Aft
Bottom	Base Bottom

QUALIFICATION TESTING

TEST LOAD – The test load was a damaged F-22 canopy (Appendix 2, Figures 2 & 3). The triaxial accelerometer used to record actual accelerations sustained by the Canopy was mounted on the canopy exterior (Appendix 2, Figures 7 & 8). The test load weight was 400 pounds.

TEST PLAN – The test plan primary references were ASTM D 4169 and SAE ARP 1967 (Appendix 1). The test methods specified in this test plan constituted the procedure for performing the tests on the container. The performance criteria for evaluation of container acceptability were specified at 50 Gs maximum and an initial and final leak rate of 0.05 psi per hour at 1.5 psi. These tests are commonly applied to special shipping containers providing rough handling protection to sensitive items. The tests were performed at AFPTEF, Building 70, Area C, Wright-Patterson AFB.

ITEM INSTRUMENTATION – The test load was instrumented with a piezoelectric triaxial accelerometer mounted on the exterior bottom painted edge between the upper and lower rows of rivets as close to the center of mass as possible (Appendix 2, Figures 7 & 8). Accelerometer axis orientations were as follows:

X Axis - Directed through container Forward and Aft sides.
Y Axis - Directed through container Top and Bottom sides (Vertical motion).
Z Axis - Directed through container Left and Right sides.

The Y and Z axis directions are rotated approximately 30 degrees counterclockwise due to the angle of the mounting surface.

See Appendix 4 for detailed accelerometer and other instrumentation information.

TEST SEQUENCES – Note: All test sequences were performed at ambient temperature and humidity.

TEST SEQUENCE 1 – Leak Test

Procedure – The desiccant port cover was removed and replaced with a port cover modified for attachment of the digital manometer and vacuum/pressure pump lines. The container was closed and sealed. The leak test was conducted at ambient temperature and pressure. The pneumatic pressure leak technique was used to pressurize the container to a minimum test pressure of 1.5 psi. Maximum allowable leak rate is 0.05 psi per hour. (Appendix 2, Figure 9).

Results – The container's leak rate was slightly greater than the maximum allowed rate of 0.05 psi per hour. Since the container is an established design, with a much-proven ability to achieve the required leak rate, this container's pre-test leak rate was recorded and testing was continued.

TEST SEQUENCE 2 – Rotational Drops

Procedure – A drop height of 12 inches was used to perform four corner and four edge drops onto the smooth steel floor of an environmental chamber, and the impact levels were recorded. The maximum allowed impact level for the item was 50 Gs. (Appendix 2, Figures 10 & 11)

Results – Due to the accelerometer's mounting location on a relatively thin surface with less than ideal rigidity and the shape and structure of the canopy, the impact waveforms show a large amount of noise, or "ringing". However, all of the recorded impact peak G data, even with the overlying noise, was well below the maximum allowed 50 Gs. There was no damage to either the container or the item. The container met the test requirements. (Appendix 3, Table 1 and Waveforms.)

TEST SEQUENCE 3 – Lateral Impact (Pendulum Impact)

Procedure – The container was placed on the pendulum test apparatus and impacted once on each of the ends. The container impact velocity was 7.3 ft/s. (Appendix 2, Figure 12)

Results – All recorded impact resultant peak G data was less than the maximum allowed 50 Gs, despite the overlying ringing. There was no damage to either the container or the item. The container met the test requirements. (Appendix 3, Table 1 and Waveforms.)

TEST SEQUENCE 4 – Vibration Test, Resonance Dwell

Procedure – The container was rigidly attached to the vibration platform. A sinusoidal vibration excitation was applied in the vertical direction and cyclically swept for 7.5 minutes at 2 minutes per octave to locate the resonant frequency. Input vibration from 5 to 12.5 Hz was at 0.125-inch double amplitude. All signals were electronically filtered using a two-pole Butterworth filter with a 600 Hz cutoff frequency. The peak transmissibility values during the up and down frequency sweeps were noted for use in determining the frequency search range for the resonance dwell test.

The vibration controller swept up the frequency range until the resonant frequency was reached. This frequency was manually tracked for a 30 minute resonance dwell test. The test was conducted at ambient temperature. (Appendix 2, Figure 13)

Results – The most significant resonant frequency of the packaged item occurred initially at 12.55 Hz, and increased slightly during the dwell period to 13.10 Hz. The Z-axis displayed the highest amplitude levels. In order to analyze this data and calculate the item transmissibility, the overlying recorded ringing described above necessitated that all vibration waveform data be filtered at 150 Hz. This filter frequency for the complex sinusoidal waveforms was conservatively

calculated as 10 times the base frequency of the one pulse. Even after filtering, the Z-axis waveform shows signs of remaining noise.

The maximum transmissibility calculated after filtering the test was 5.7, which slightly exceeded the design goal of 5 Hz when the resonant frequency is less than 15 Hz. Since the filtered Z-axis data still displayed noise and contributed to a higher transmissibility value, and the resonant frequency is approaching 15 Hz, this transmissibility is acceptable. At the end of the test period, there was no damage to the container or item. The container met the test requirements. (Appendix 3, Table 2 and Waveforms)

TEST SEQUENCE 5 – Leak Test

Procedure – Test Sequence 1 was repeated.

Results – The container leak rate did not change.

TEST CONCLUSIONS – No damage occurred during the above testing to the container, isolation system or test item. All impact levels are well below the item fragility limit of 50 Gs. Therefore, the container and mounting system do provide adequate protection for the canopy.

FIT & FUNCTION TESTING

Fit and function testing was completed on site at AFPTEF with the F22 Canopy that was supplied for prototype testing.

CONCLUSIONS

No damage occurred during the above testing to the container, mounting system or test item. There was no evidence of any contact or impact between the Canopy and the container walls or lid. All impact levels were well below the item fragility limit of 50 Gs. The CNU-692/E aluminum container was accepted by the F-22 Program Office at Wright-Patterson AFB and Lockheed-Martin Aeronautics. The container met all the user's requirements. The container can protect a F-22 Canopy during world-wide transportation and storage and will save the Air Force tens of thousands of dollars in O&M costs.

RECOMMENDATIONS

AFPTEF recommends that new containers be procured and delivered to avoid damage to F-22 Canopies currently in the logistics cycle, thus mitigating overall shipping risks. All wood crates for the canopy should be replaced.

APPENDIX 1: Test Plan

AF PACKAGING TECHNOLOGY AND ENGINEERING FACILITY (Container Test Plan)					**AFPTEF PROJECT NUMBER:** 06-P-112	
CONTAINER SIZE (L x W x D) **INTERIOR:**	**EXTERIOR:**	**WEIGHT (LBS)** **GROSS:**	**ITEM:**	**CUBE (CU. F)**	**QUANTITY:**	**DATE:**
145.6 x 55.7 x 42.6	148.4 x 58.5 x 51.3	1721	400	257.7	1	May 07
ITEM NAME: F-22 Canopy				**MANUFACTURER:**		
CONTAINER NAME: Reusable Shipping & Storage Container					**CONTAINER COST:**	
PACK DESCRIPTION: Extruded Aluminum Container, Test Load of a F-22 Canopy						
CONDITIONING: As noted below						

TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRU-MENTATION
		NOTE No damage to contents is acceptable and Package must be in serviceable condition. Serviceable means remains sealed, with no deformities, etc.		
		Quality Conformance Tests		
1.	**Examination of Product.**			
	SAE ARP 1967 **Par. 4.5.1** **Table I**	Container shall be carefully examined to determine conformance with material, workmanship, and requirements as specified in Table and drawings.	Ambient temp.	Visual Inspection (VI)
2.	**Weight Test.**			
	SAE ARP 1967 **Par. 4.5.8.3.7**	Container with canopy shall be weighed.	Ambient temp.	Scale
		Performance Tests		
3.	**Leak Test.**			
	SAE ARP 1967 **Par. 4.5.2**	Pneumatic pressure at 1.5 psi. After temperature stabilization, pressure drop shall not exceed 0.05 psi per hour. Perform leak test again at end of test series.	Ambient temp.	Pressure Transducer (PT)

COMMENTS:	
PREPARED BY: Joel A. Sullivan, Mechanical Engineer	**APPROVED BY:** Robbin L. Miller, Chief AFPTEF

AF PACKAGING TECHNOLOGY AND ENGINEERING FACILITY (Container Test Plan)					**AFPTEF PROJECT NUMBER:** 06-P-112	
CONTAINER SIZE (L x W x D) **INTERIOR:**	**EXTERIOR:**	**WEIGHT** **GROSS:**	**ITEM:**	**CUBE (CU. F)**	**QUANTITY:**	**DATE:**
145.6 x 55.7 x 42.6	148.4 x 58.5 x 51.3	1721	400	257.7	1	May 07
ITEM NAME: F-22 Canopy				**MANUFACTURER:**		
CONTAINER NAME: Reusable Shipping & Storage Container					**CONTAINER COST:**	
PACK DESCRIPTION: Extruded Aluminum Container, Test Load of a F-22 Canopy						
CONDITIONING: As noted below						

TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRU-MENTATION
4.	**Rotational Drop Tests (Ambient Temperature).**			
	SAE ARP 1967 **Par. 4.5.3** **ASTM D 4169** **ASTM D 6179** **Methods A&B**	Drop height shall be 12 inches. Item shall not sustain more than 50G's.	One drop on all bottom corners (4 drops) and one drop on all edges (4 drops).	VI Tri-axial Accelerometer
5.	**Vibration Test, Resonance Sweep and Dwell.**			
	SAE ARP 1967 **Par. 4.5.5** **ASTM D 4169** **ASTM D 999**	The container shall be vibrated from 5 Hz to 50 Hz at a sweep rate of one half octave per minute with a total sweep time of 7.5 minutes. Container shall then be vibrated for 30 minutes at the predominant resonance. Input excitation shall be 0.125 in double amplitude or 1 G limits.	Ambient temp. Rigidly attach container to exciter	VI and Tri-axial Accelerometer
6.	**Lateral Impact Test (Ambient Temperature).**			
	SAE ARP 1967 **Par. 4.5.6** **ASTM D 4169** **ASTM D 880** **Procedure B**	Impact velocity 7.3 ft/s. Item shall not sustain more than 50G's.	One impact on each end (2 impacts).	VI and Tri-axial Accelerometer

COMMENTS:	
PREPARED BY: Joel A. Sullivan, Mechanical Engineer	**APPROVED BY:** Robbin L. Miller, Chief AFPTEF

AF PACKAGING TECHNOLOGY AND ENGINEERING FACILITY (Container Test Plan)					**AFPTEF PROJECT NUMBER:** 06-P-112	
CONTAINER SIZE (L x W x D) **INTERIOR:** 145.6 x 55.7 x 42.6	**EXTERIOR:** 148.4 x 58.5 x 51.3	**WEIGHT GROSS:** 1721	**ITEM:** 400	**CUBE (CU. F)** 257.7	**QUANTITY:** 1	**DATE:** May 07
ITEM NAME: F-22 Canopy				**MANUFACTURER:**		
CONTAINER NAME: Reusable Shipping & Storage Container					**CONTAINER COST:**	
PACK DESCRIPTION: Extruded Aluminum Container, Test Load of a F-22 Canopy						
CONDITIONING: As noted below						

TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRU-MENTATION
7.	**<u>Leak Test</u>.** **SAE ARP 1967 Par. 4.5.2**	Pneumatic pressure at 1.5 psi. After temperature stabilization, pressure drop shall not exceed 0.05 psi per hour. Perform leak test again at end of test series.	Ambient temp.	Pressure Transducer (PT)

COMMENTS:

PREPARED BY Joel A. Sullivan, Mechanical Engineer	**APPROVED BY** Robbin L. Miller, Chief AFPTEF

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APPENDIX 2: Fabrication & Testing Photographs

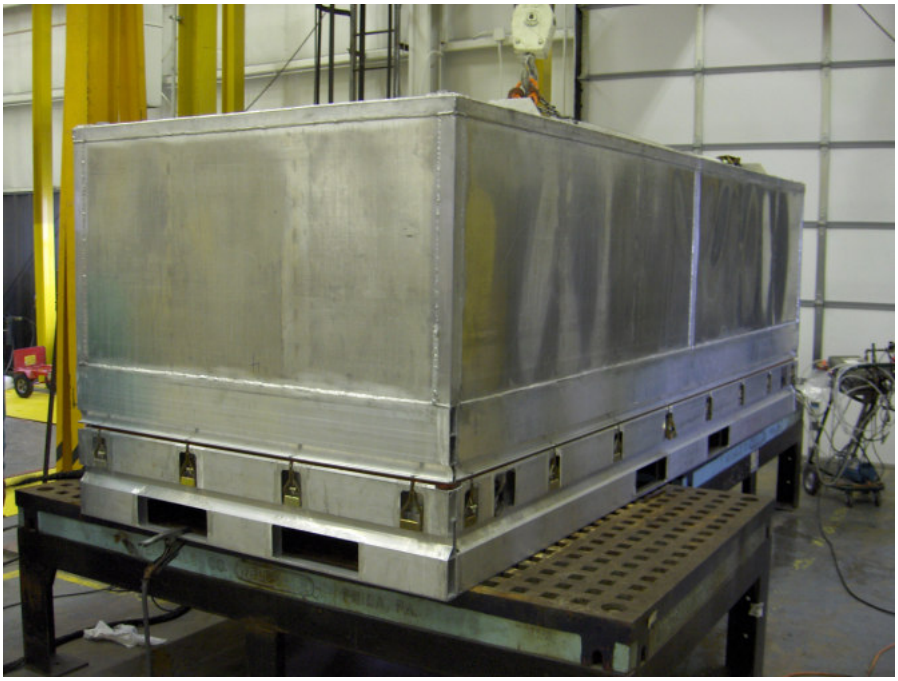


Figure 1. Closed Container.

Figure 2. Canopy in container base (side view).

Figure 3. Canopy in container base (fwd view) and sling clearance.

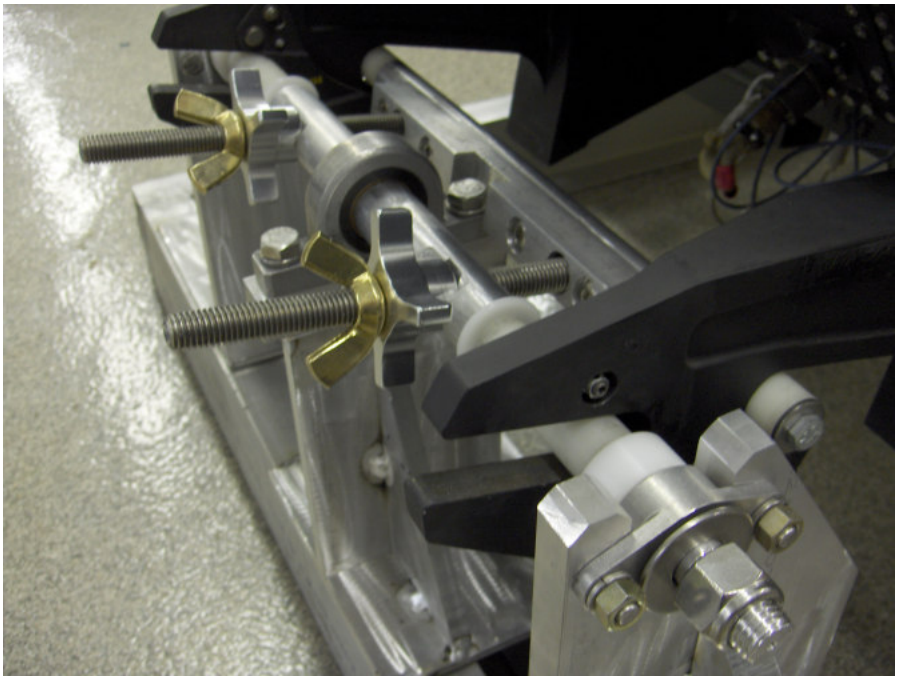


Figure 4. Fwd Attachment Point

Figure 5. Aft Attachment Point

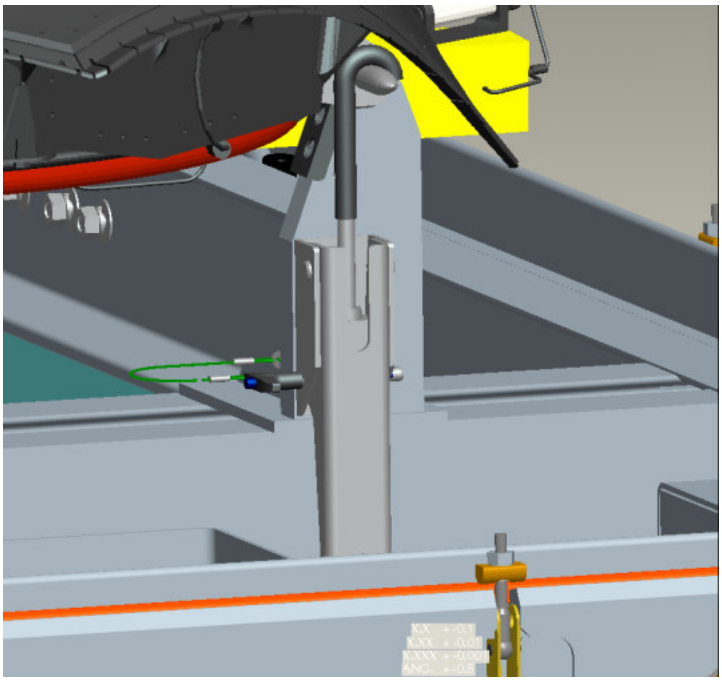


Figure 6. Locked Aft Attachment Point
(Computer Generated)

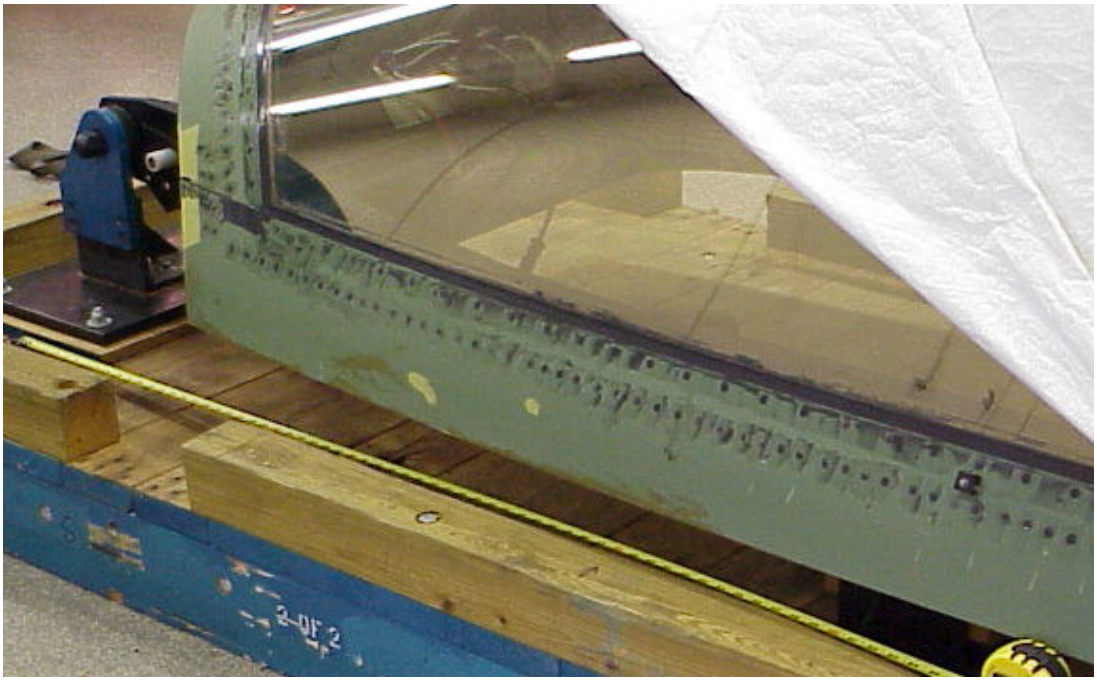


Figure 7. Placement of accelerometer on the canopy.

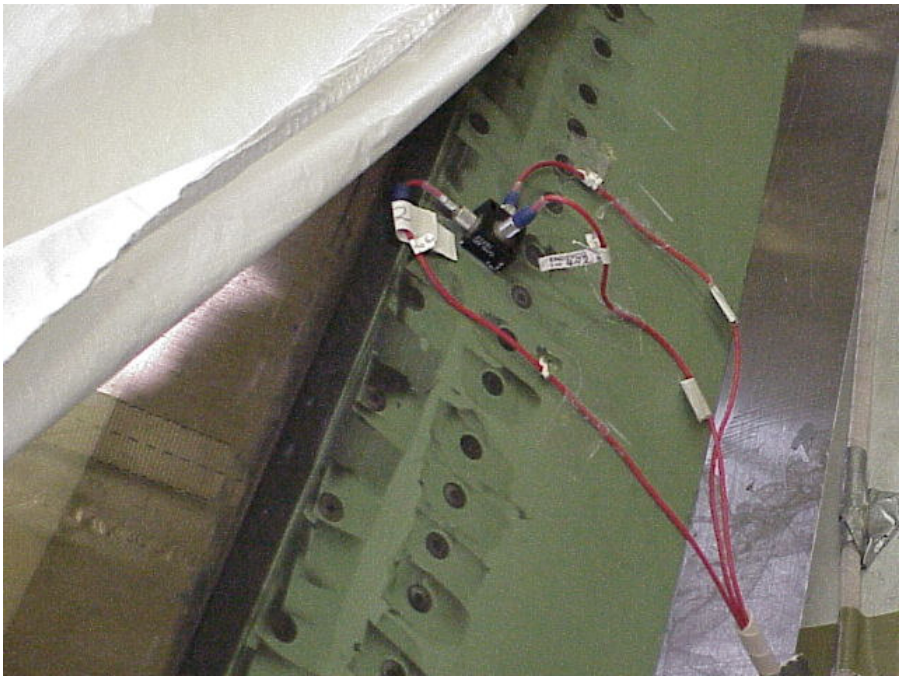


Figure 8. Close-up of accelerometer on the canopy.

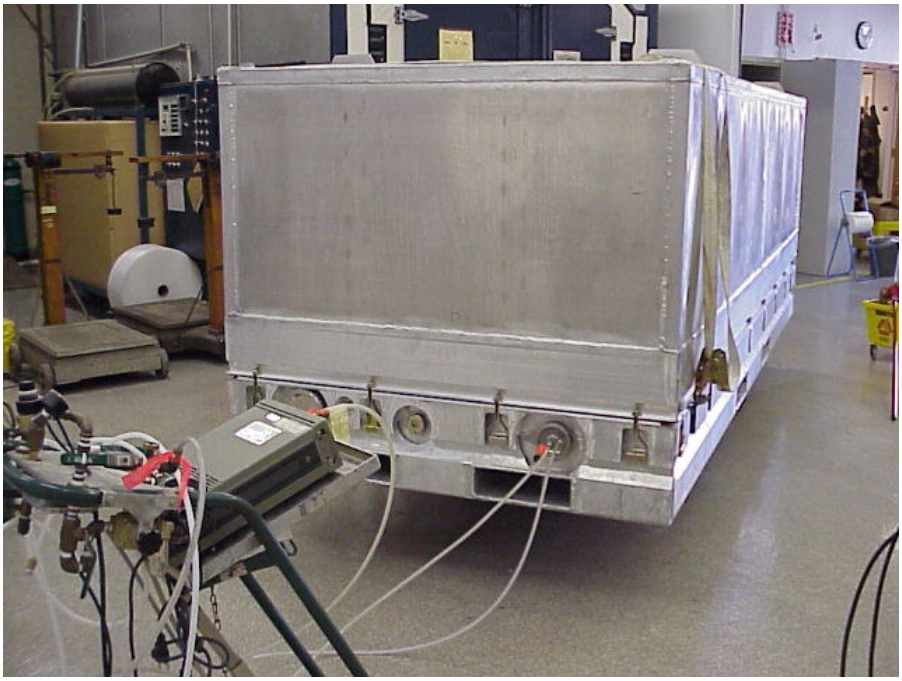


Figure 9. Pressure Test Set-up.

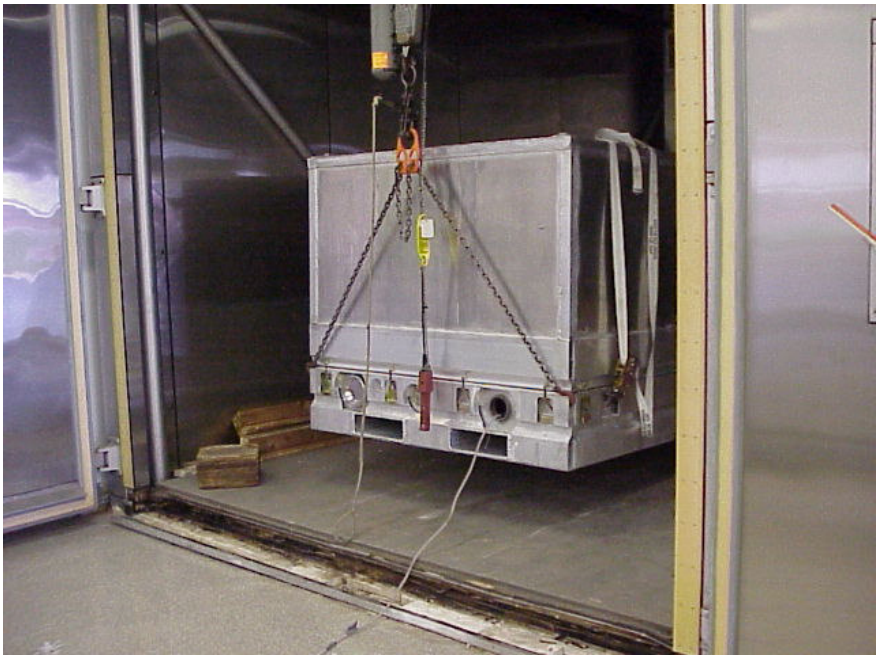


Figure 10. Rotational Edge Drop.

Figure 11. Rotational Corner Drop.

Figure 12. Pendulum Impact Test.

Figure 13. Resonance Sweep and Dwell Test.

APPENDIX 3: Test Data

Table 1. Reaper Engine Impact Test Summary

IMPACT TYPE	TEST TEMPERATURE	IMPACT LOCATION	RESULTANT PEAK G
ROTATIONAL - EDGE	ambient	forward-bottom	24
ROTATIONAL - EDGE	ambient	aft-bottom	23
ROTATIONAL - EDGE	ambient	left-bottom	30
ROTATIONAL - EDGE	ambient	right-bottom	17
ROTATIONAL - CORNER	ambient	forward-left	27
ROTATIONAL - CORNER	ambient	forward-right	29
ROTATIONAL - CORNER	ambient	aft-left	20
ROTATIONAL - CORNER	ambient	aft-right	21
LATERAL IMPACT - FACE	ambient	forward	31
LATERAL IMPACT - FACE	ambient	aft	32

TABLE 2. Container Resonant Frequency and Transmissibility Values

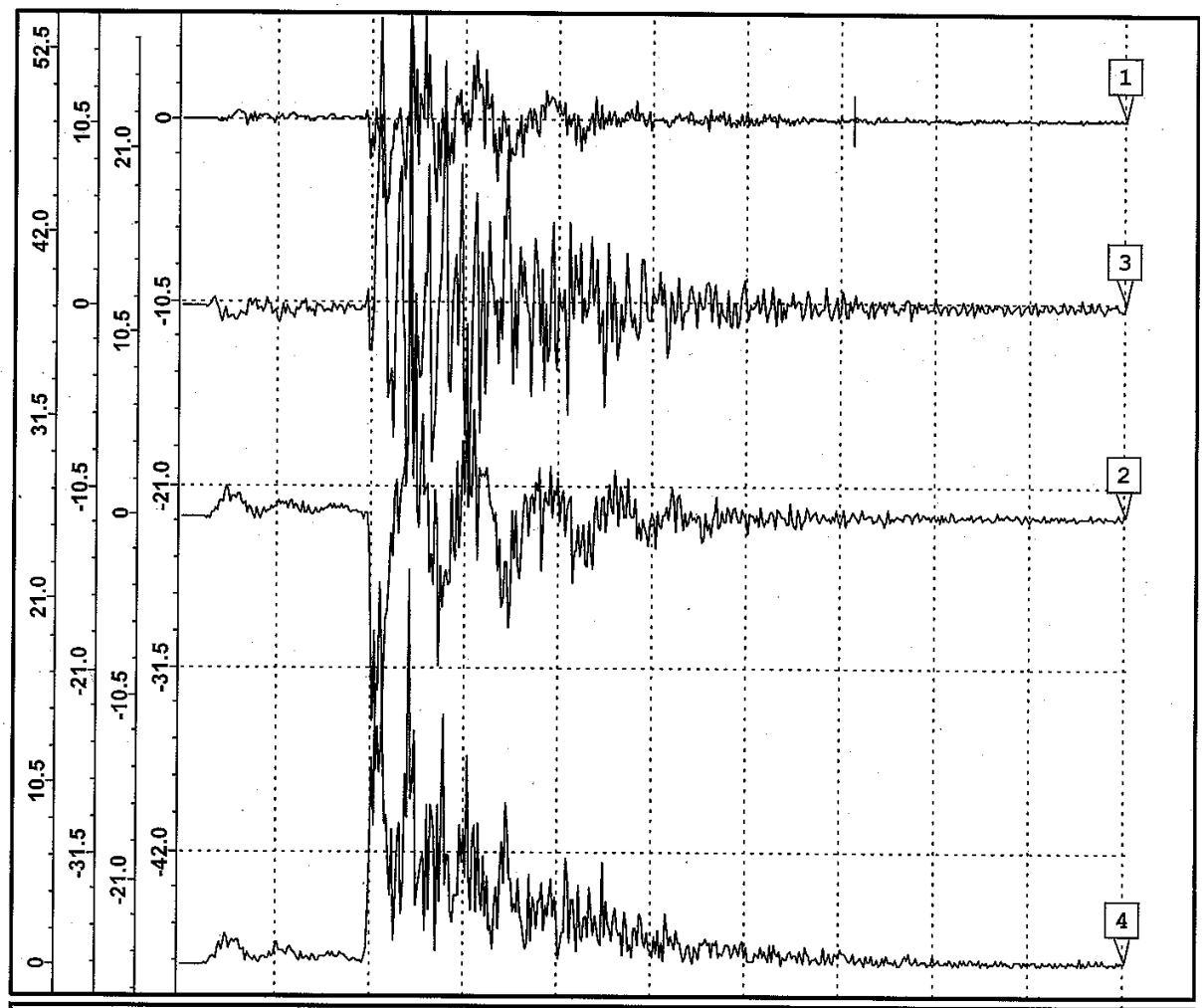
TEST TEMPERATURE	DWELL TIME	RESONANT FREQUENCY	TRANSMISSIBILITY
Ambient	3 min	13.10 Hz	5.7
Ambient	15 min	12.85 Hz	5.7
Ambient	30 min	12.55 Hz	5.3

F22 CANOPY

ROTATIONAL DROP TEST

Time:	May 9 2007 13:55	Test Engineer:	Evans
Test Type:	Edge	Impact Point:	Foward bottom edge
Container/Item:	Aluminum/F22 Canopy	Drop Height:	12 inches

V. Angle: 87.08;H.Angle: 29.81;



	Ch.	Time		Curr Amp	Peak Amp	1st Int	Time/Div		Hexp	Vexp
◉	1	931.	mS	0.02 g's	10.02 g's	-11.78 In/s	131	mS	1	2
○	2	931.	mS	0.36 g's	22.79 g's	-19.90 In/s	131	mS	1	2
○	3	931.	mS	0.21 g's	-17.96 g's	33.00 In/s	131	mS	1	2
○	R	931.	mS	0.42 g's	23.63 g's	40.30 In/s	131	mS	1	2

Remarks

Peak Gs X: 10 Y: 23 Z: 18 Peak Gs Resultant: 24

Ch.1=X(fwd-aft); Ch.2=Y(vertical); Ch.3=Z(left-right); Ch.4=Resultant.

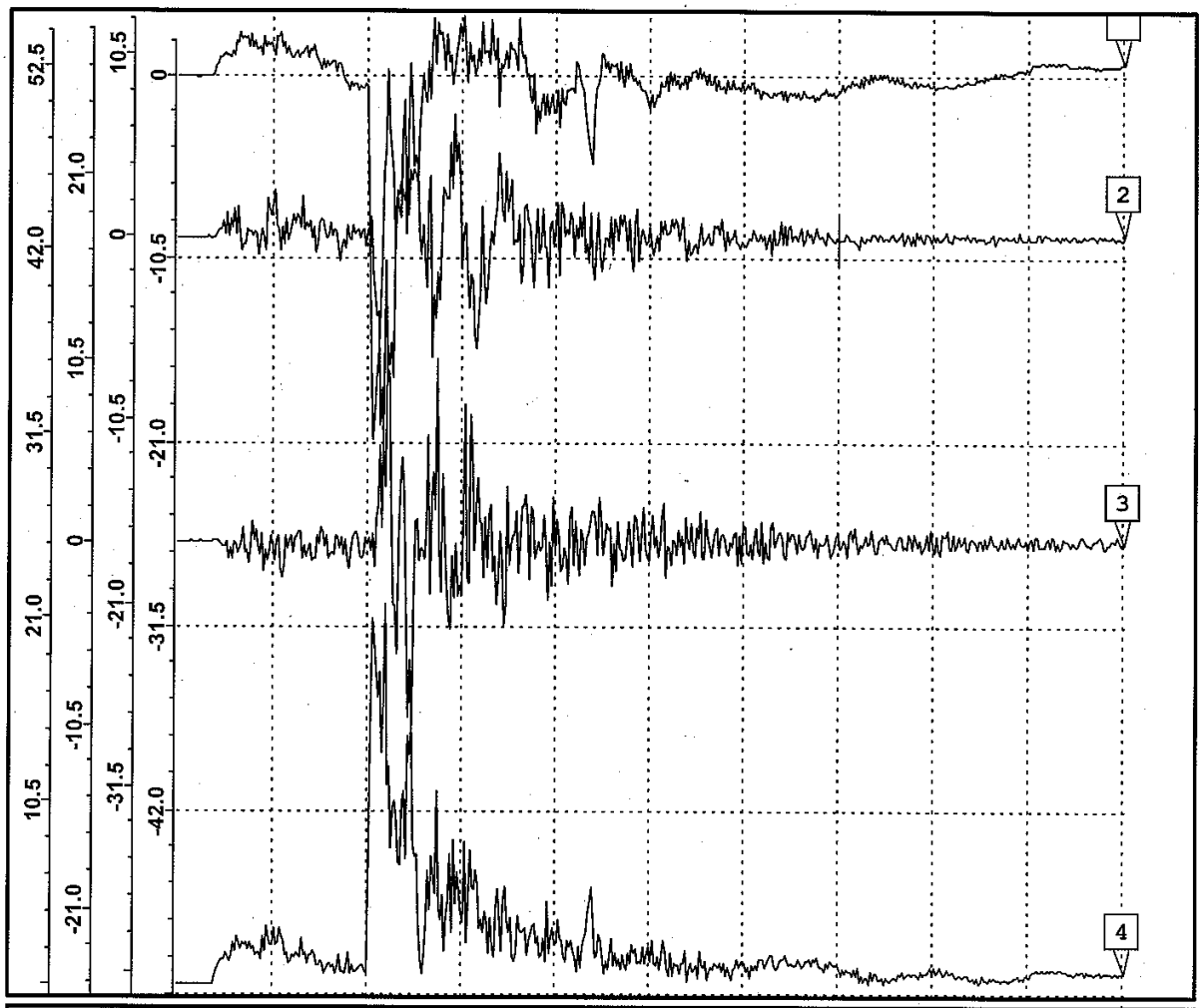
**Aft Side = desiccant port side. Ambient temperature and humidity.
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16473.**

F22 CANOPY

ROTATIONAL DROP TEST

Time:	May 23 2007 15:07	Test Engineer:	Evans
Test Type:	Edge	Impact Point:	Aft bottom edge
Container/Item:	Aluminum/F22 Canopy	Drop Height:	12 inches

V. Angle: 149.80;H.Angle: 112.14;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	913. mS	-0.90 g's	-21.05 g's	-208.68 In/s	131 mS	1	2
2	913. mS	-0.20 g's	-14.88 g's	24.83 In/s	131 mS	1	2
3	913. mS	0.49 g's	17.17 g's	15.57 In/s	131 mS	1	2
R	913. mS	1.11 g's	22.61 g's	210.73 In/s	131 mS	1	2

Remarks

Peak Gs X: 21 Y: 15 Z: 17 Peak Gs Resultant: 23
AFT BOTTOM EDGE RETEST WITH DRAW LATCHES.
Ch.1=X(fwd-aft); Ch.2=Y(vert.); Ch.3=Z(left-right). Ch4=Resultant.

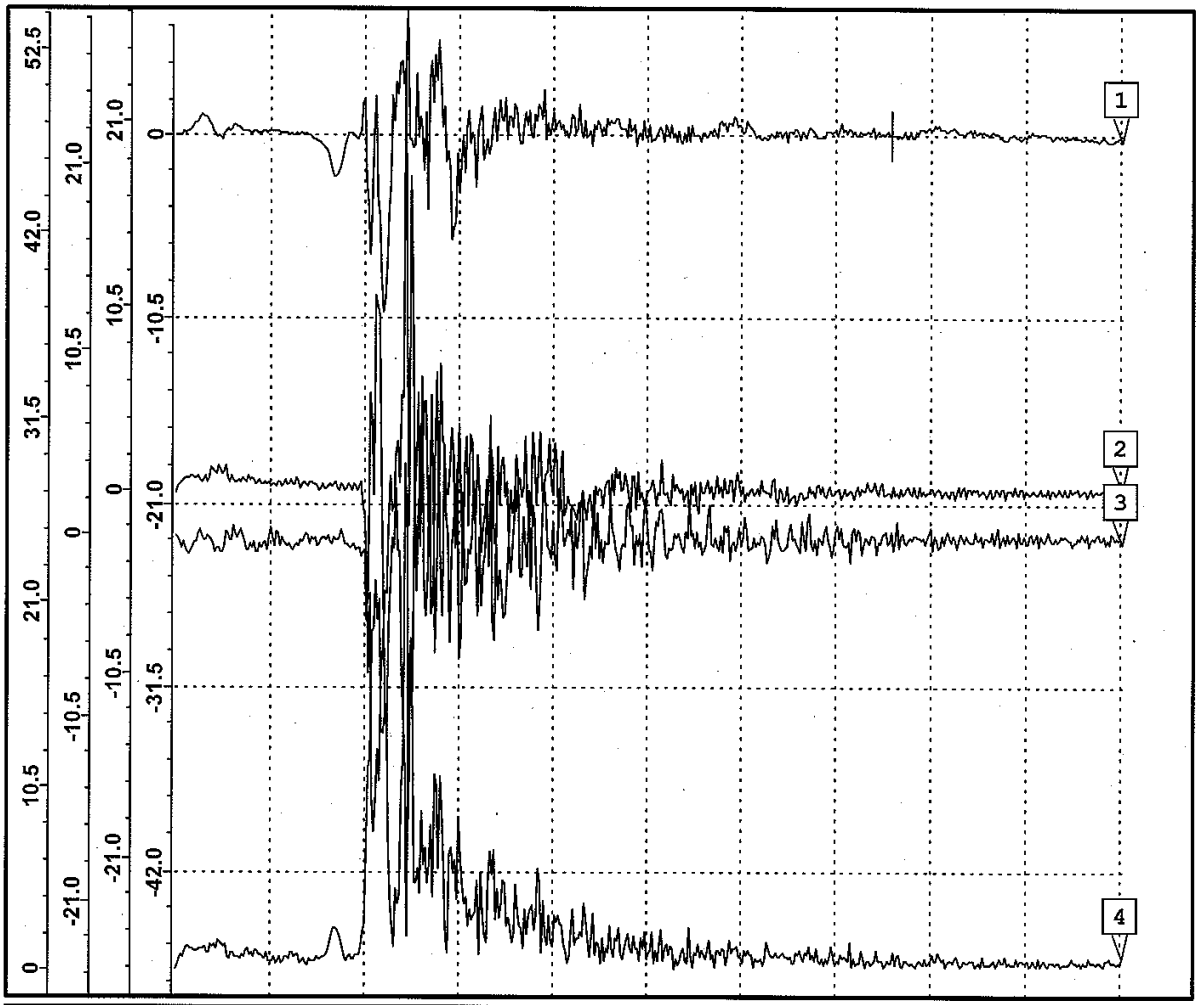
Aft Side = desiccant port end. Ambient temperature/humidity.
ASTM D4169, ASTM D6179. SAE ARP 1967. Accel. S/N 16743.

F22 CANOPY

ROTATIONAL DROP TEST

Time:	May 9 2007 14:19	Test Engineer:	Evans
Test Type:	Edge	Impact Point:	Left bottom edge
Container/Item:	Aluminum/F22 Canopy	Drop Height:	12 inches

V. Angle: 94.13;H.Angle: 149.17;



	Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
◉	1	990. mS	-0.03 g's	12.01 g's	22.42 In/s	131 mS	1	2
○	2	990. mS	-0.36 g's	28.37 g's	-8.59 In/s	131 mS	1	2
○	3	990. mS	0.21 g's	-23.57 g's	-168.54 In/s	131 mS	1	2
○	R	990. mS	0.42 g's	29.86 g's	170.24 In/s	131 mS	1	2

Remarks

Peak Gs X: 12 Y: 28 Z: 24 Peak Gs Resultant: 30

Ch.1=X(fwd-aft); Ch.2=Y(vertical); Ch.3=Z(left-right); Ch.4=Resultant.

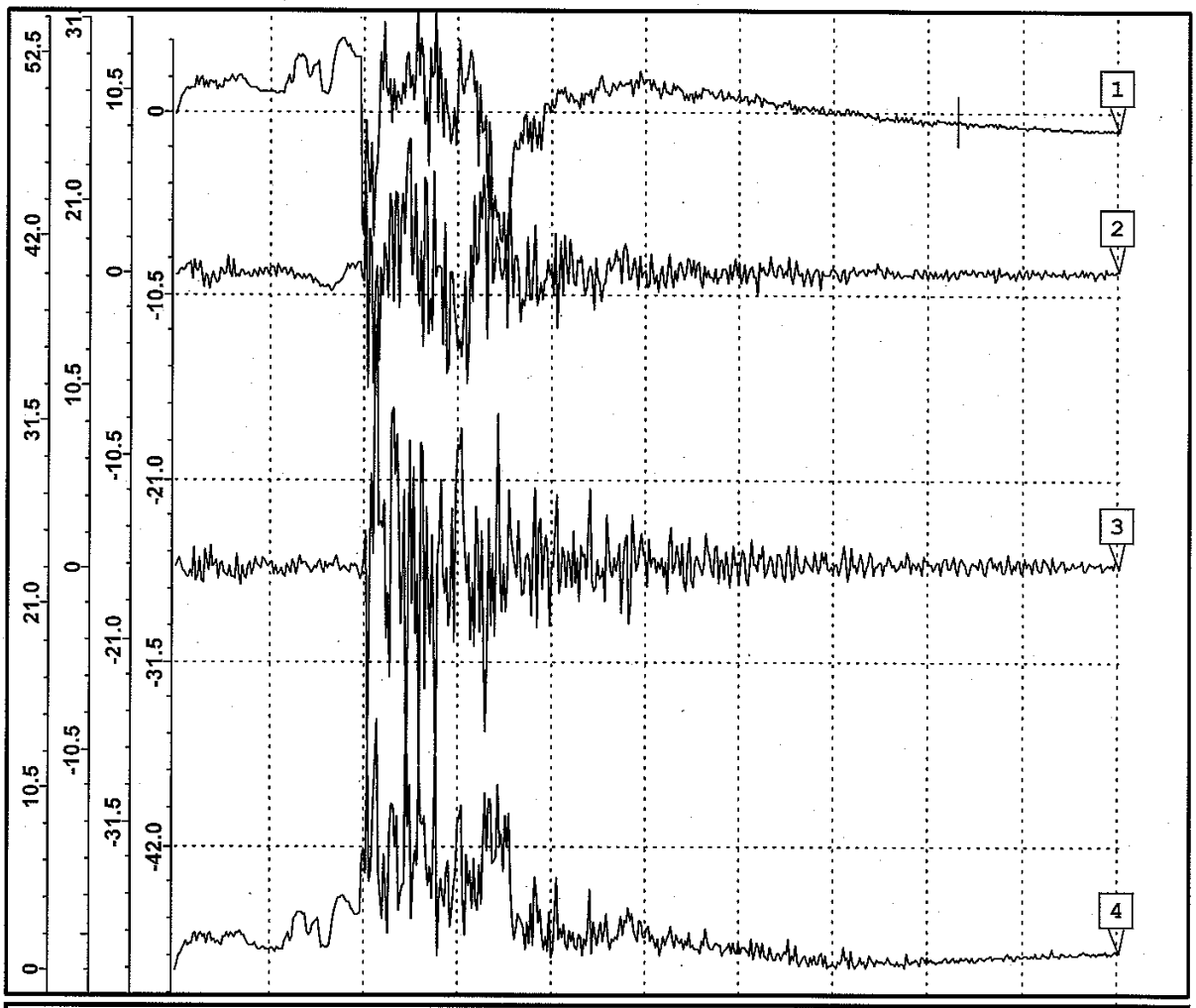
Aft Side = desiccant port side. Ambient temperature and humidity.
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16473.

F22 CANOPY

ROTATIONAL DROP TEST

Time:	May 9 2007 14:26	Test Engineer:	Evans
Test Type:	Edge	Impact Point:	Right bottom edge
Container/Item:	Aluminum/F22 Canopy	Drop Height:	12 inches

V. Angle: 138.24;H.Angle: 249.80;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	1.09 S	-0.46 g's	-9.38 g's	282.67 In/s	131 mS	1	2
2	1.09 S	-0.14 g's	11.38 g's	50.86 In/s	131 mS	1	2
3	1.09 S	-0.39 g's	15.96 g's	89.11 In/s	131 mS	1	2
R	1.09 S	0.62 g's	16.62 g's	300.71 In/s	131 mS	1	2

Remarks

Peak Gs X: 9 Y: 11 Z: 16 Peak Gs Resultant: 17

Ch.1=X(fwd-aft); Ch.2=Y(vertical); Ch.3=Z(left-right); Ch.4=Resultant.

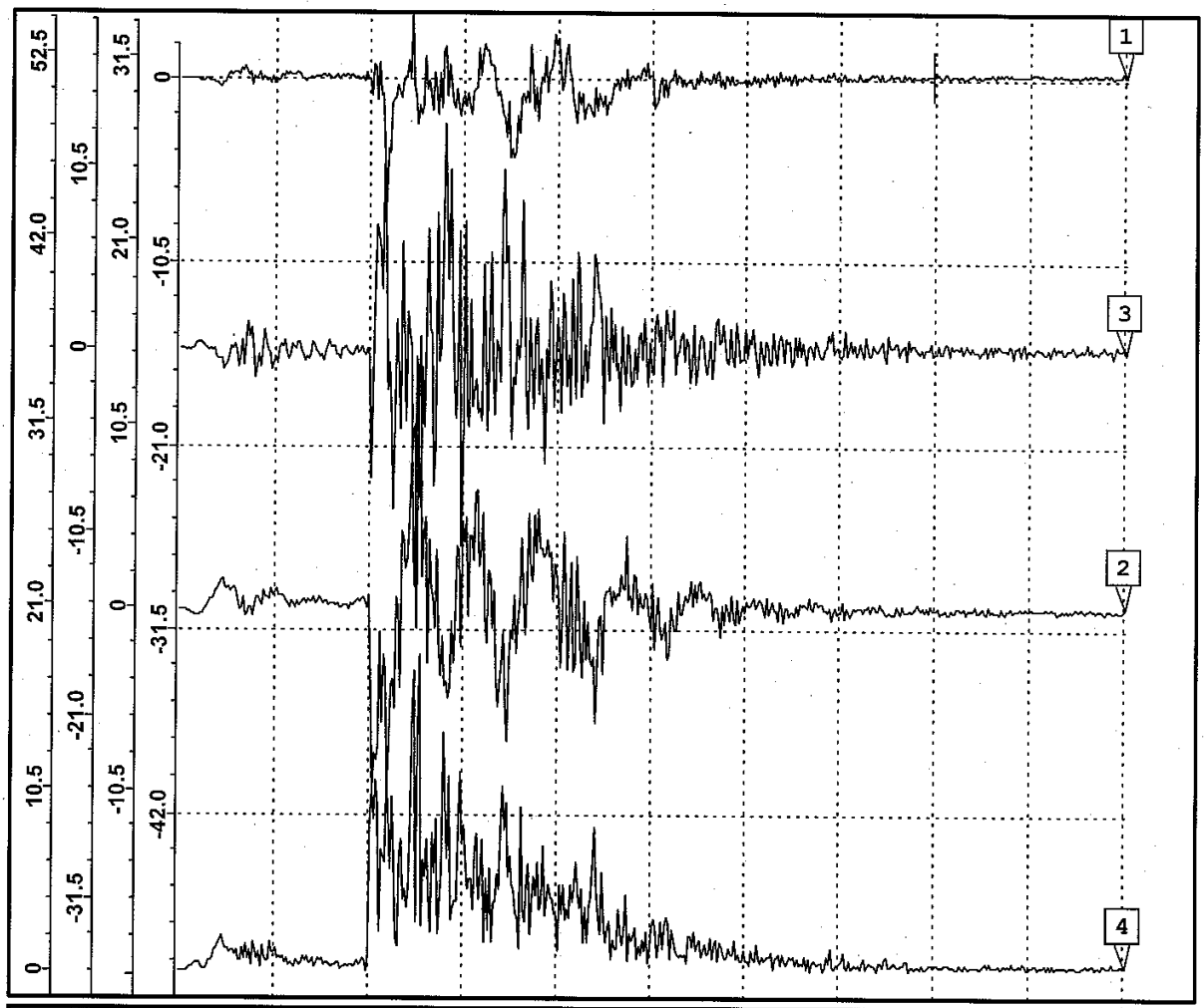
Aft Side = desiccant port side. Ambient temperature and humidity.
ASTM D4169 ASTM D6179 SAE ARP 1967 Accelerometer S/N 16473

F22 CANOPY

ROTATIONAL DROP TEST

Time:	May 9 2007 14:08	Test Engineer:	Evans
Test Type:	Corner	Impact Point:	Forward left corner
Container/Item:	Aluminum/F22 Canopy	Drop Height:	12 inches

V. Angle: 64.91;H.Angle: 258.05;



	Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
◉	1	1.04 S	0.17 g's	8.36 g's	-91.58 In/s	131 mS	1	2
○	2	1.04 S	-0.08 g's	26.61 g's	23.18 In/s	131 mS	1	2
○	3	1.04 S	-0.36 g's	-17.30 g's	13.82 In/s	131 mS	1	2
○	R	1.04 S	0.41 g's	26.79 g's	95.47 In/s	131 mS	1	2

Remarks

Peak Gs X: 6 Y: 27 Z: 17 Peak Gs Resultant: 27

Ch.1=X(fwd-aft); Ch.2=Y(vertical); Ch.3=Z(left-right); Ch.4=Resultant.

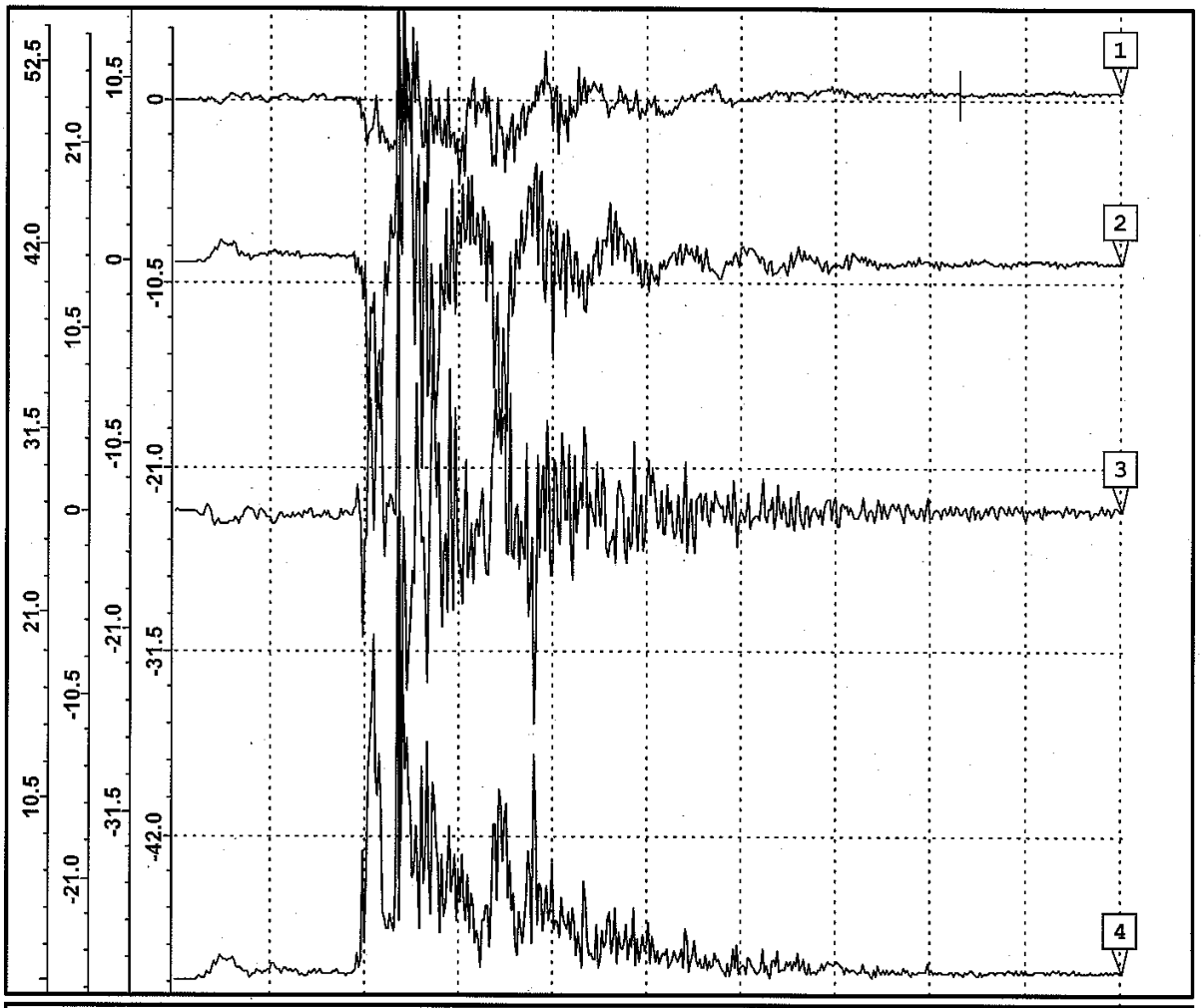
**Aft Side = desiccant port side. Ambient temperature and humidity.
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16473.**

F22 CANOPY

ROTATIONAL DROP TEST

Time:	May 9 2007 13:59	Test Engineer:	Evans
Test Type:	Corner	Impact Point:	Forward right
Container/Item:	Aluminum/F22Canopy	Drop Height:	12 inches

V. Angle: 24.02;H.Angle: 246.51;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	1.09 S	0.38 g's	7.24 g's	-67.62 In/s	131 mS	1	2
2	1.09 S	-0.07 g's	25.73 g's	18.55 In/s	131 mS	1	2
3	1.09 S	-0.15 g's	-25.11 g's	-2.84 In/s	131 mS	1	2
R	1.09 S	0.41 g's	28.58 g's	70.17 In/s	131 mS	1	2

Remarks

Peak Gs X: 7 Y: 26 Z: 25 Peak Gs Resultant: 29

Ch.1=X(fwd-aft); Ch.2=Y(vertical); Ch.3=Z(left-right); Ch.4=Resultant.

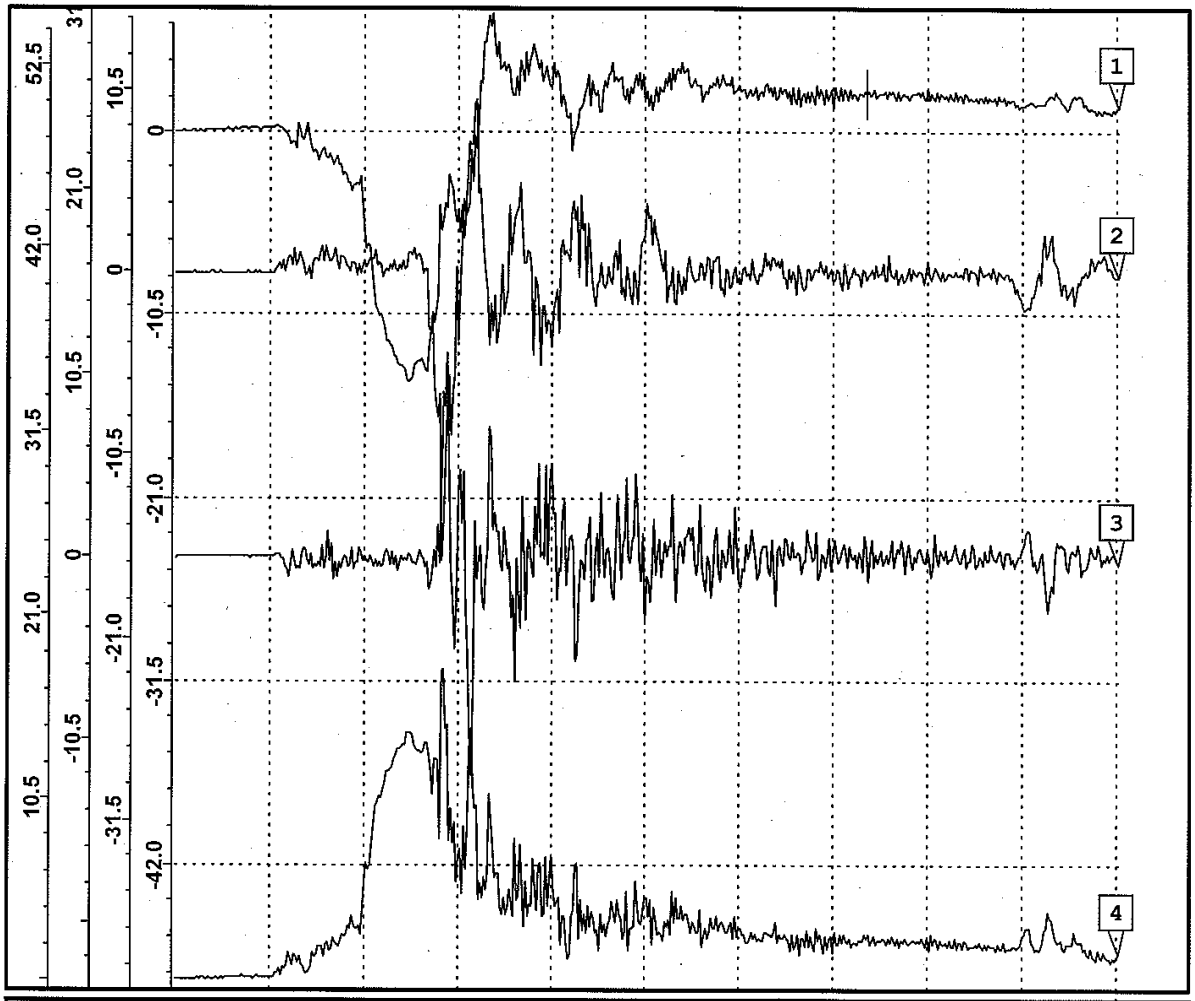
**Aft Side = desiccant port side. Ambient temperature and humidity.
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16473.**

F22 CANOPY

ROTATIONAL DROP TEST

Time:	May 23 2007 15:31	Test Engineer:	Evans
Test Type:	Corner	Impact Point:	Aft left corner
Container/Item:	Aluminum/F22 Canopy	Drop Height:	12 inches

V. Angle: 15.33;H.Angle: 135.42;



	Ch.	Time		Curr Amp	Peak Amp	1st Int	Time/Div		Hexp	Vexp
◉	1	960.	mS	2.26 g's	-14.52 g's	-55.07 In/s	131	mS	1	2
○	2	960.	mS	-0.44 g's	-17.23 g's	-3.29 In/s	131	mS	1	2
○	3	960.	mS	0.43 g's	12.59 g's	13.84 In/s	131	mS	1	2
○	R	954.	mS	2.38 g's	20.26 g's	56.87 In/s	131	mS	1	2

Remarks

Peak Gs X: 15 Y: 17 Z: 13 Peak Gs Resultant: 20
Aft left retest with draw latches.
Ch.1=X(fwd-aft); Ch.2=Y(vertical); Ch.3=Z(left-right); Ch.4=Resultant.

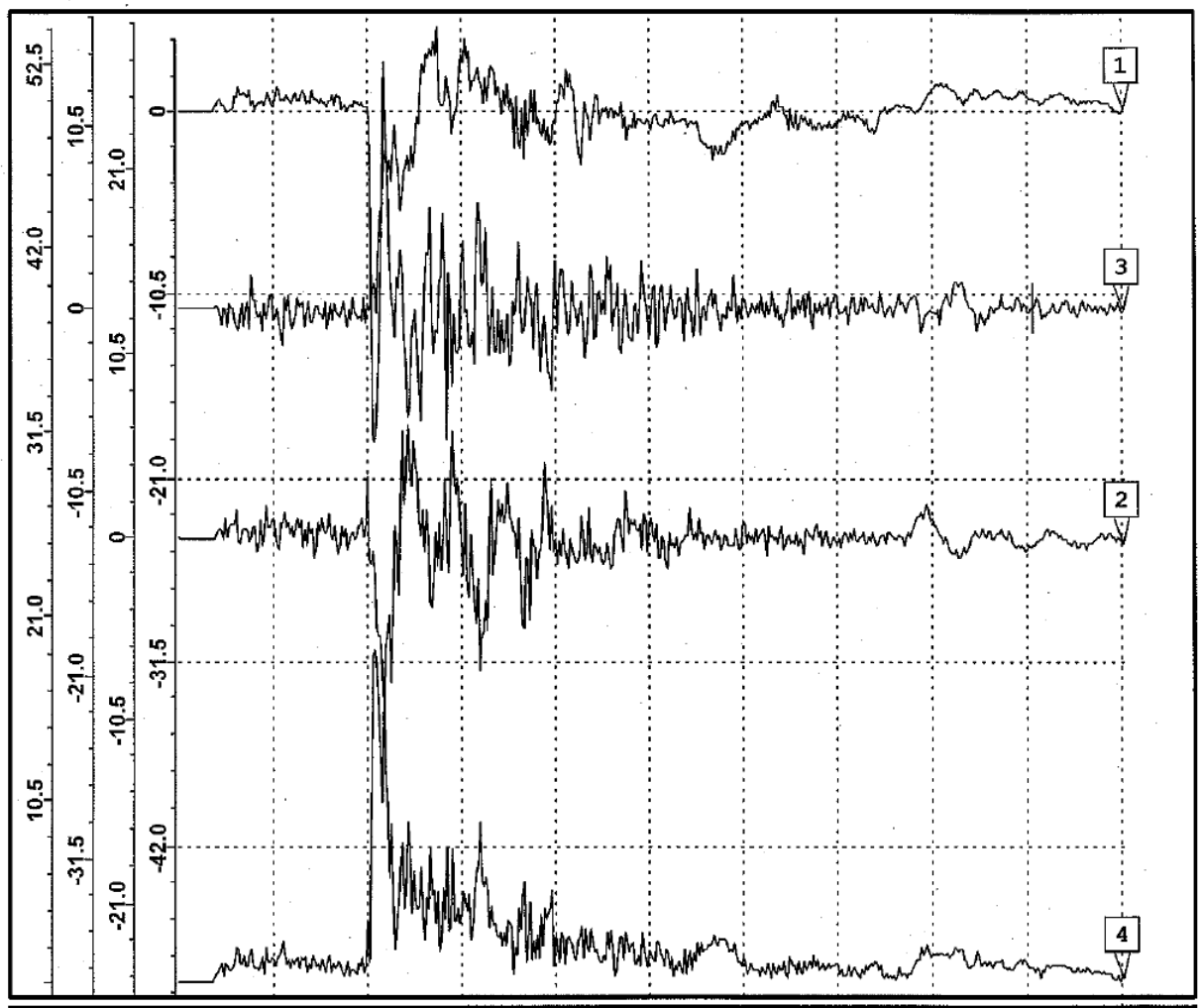
Aft Side = desiccant port side. Ambient temperature and humidity.
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16473.

F22 CANOPY

ROTATIONAL DROP TEST

Time:	May 23 2007 15:17	Test Engineer:	Evans
Test Type:	Edge	Impact Point:	Aft right corner
Container/Item:	Aluminum/F22 Canopy	Drop Height:	12 inches

V. Angle: 29.35;H.Angle: 181.13;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	1.18 S	0.74 g's	-20.28 g's	-67.93 In/s	131 mS	1	2
2	1.18 S	-0.42 g's	-10.89 g's	-22.32 In/s	131 mS	1	2
3	1.18 S	-0.01 g's	14.92 g's	0.15 In/s	131 mS	1	2
R	1.18 S	0.85 g's	20.74 g's	71.51 In/s	131 mS	1	2

Remarks

Peak Gs X: 20 Y: 11 Z: 15 Peak Gs Resultant: 21
Aft right retest with draw latches.
Ch.1=X(fwd-aft) ; Ch.2=Y(vertical) ; Ch.3=Z(left-right) ; Ch.4=Resultant

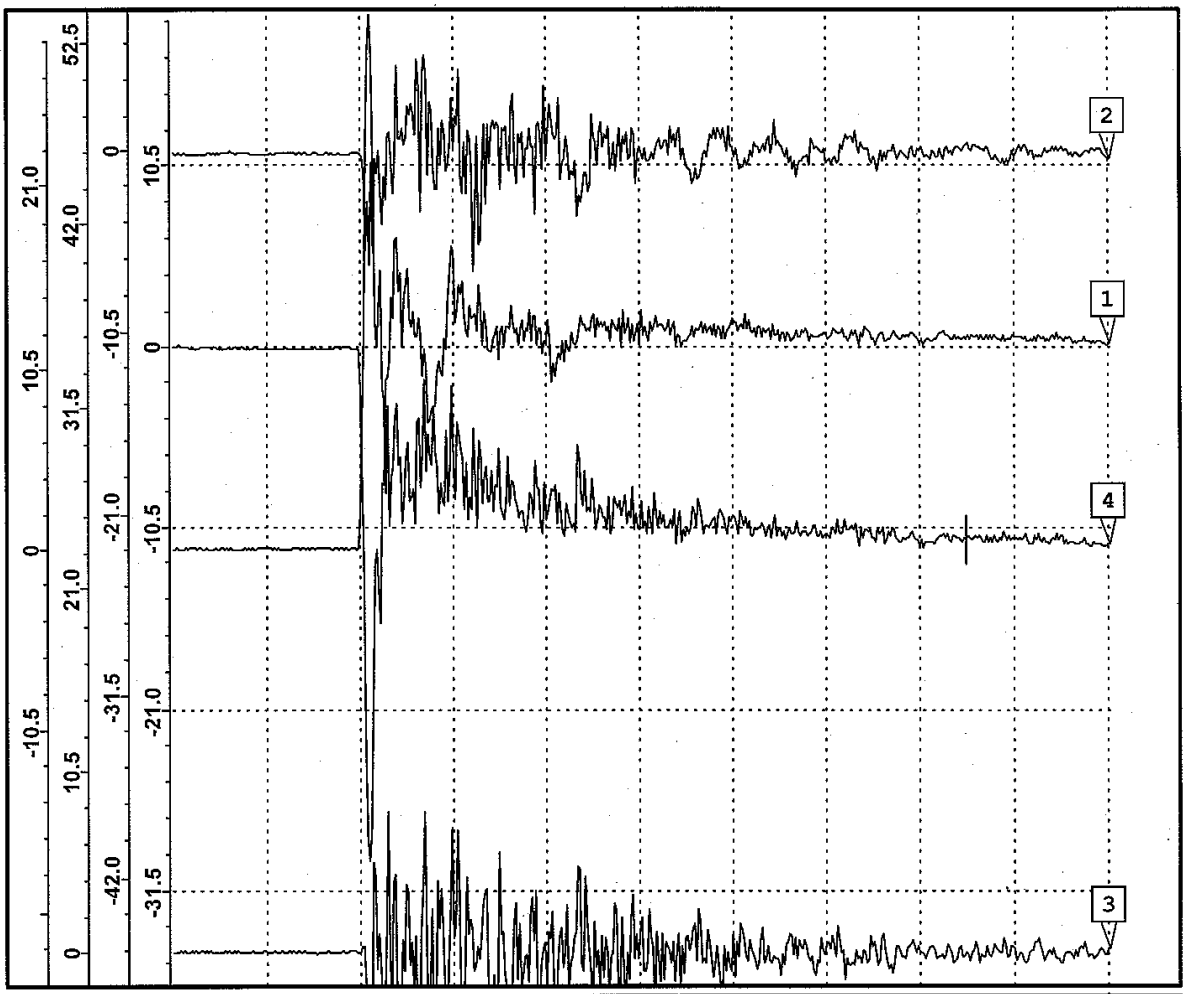
Aft Side = desiccant port side. Ambient temperature and humidity.
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16473.

F22 CANOPY

PENDULUM IMPACT TEST

Time:	**May 24 2007 10:17**	**Test Engineer:**	**Evans**
Test Type:	**Pendulum**	**Impact Point:**	**Forward side**
Container/Item:	**Aluminum/F22 Canopy**	**Impact Velocty:**	**7.3 ft/s**

V. Angle: 43.58;H.Angle: 358.53;



	Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
○	1	1.11 S	0.49 g's	-29.73 g's	35.14 In/s	131 mS	1	2
○	2	1.11 S	0.47 g's	-12.79 g's	20.63 In/s	131 mS	1	2
○	3	1.11 S	-0.01 g's	-13.53 g's	-10.51 In/s	131 mS	1	2
◉	R	1.11 S	0.68 g's	30.93 g's	42.08 In/s	131 mS	1	2

Remarks

Peak Gs X: 30 Y: 13 Z: 14 Peak Gs Resultant: 31

Ch.1=X(fwd-aft); Ch.2=Y(vertical); Ch.3=Z(left-right).
Ch.4=Resultant.

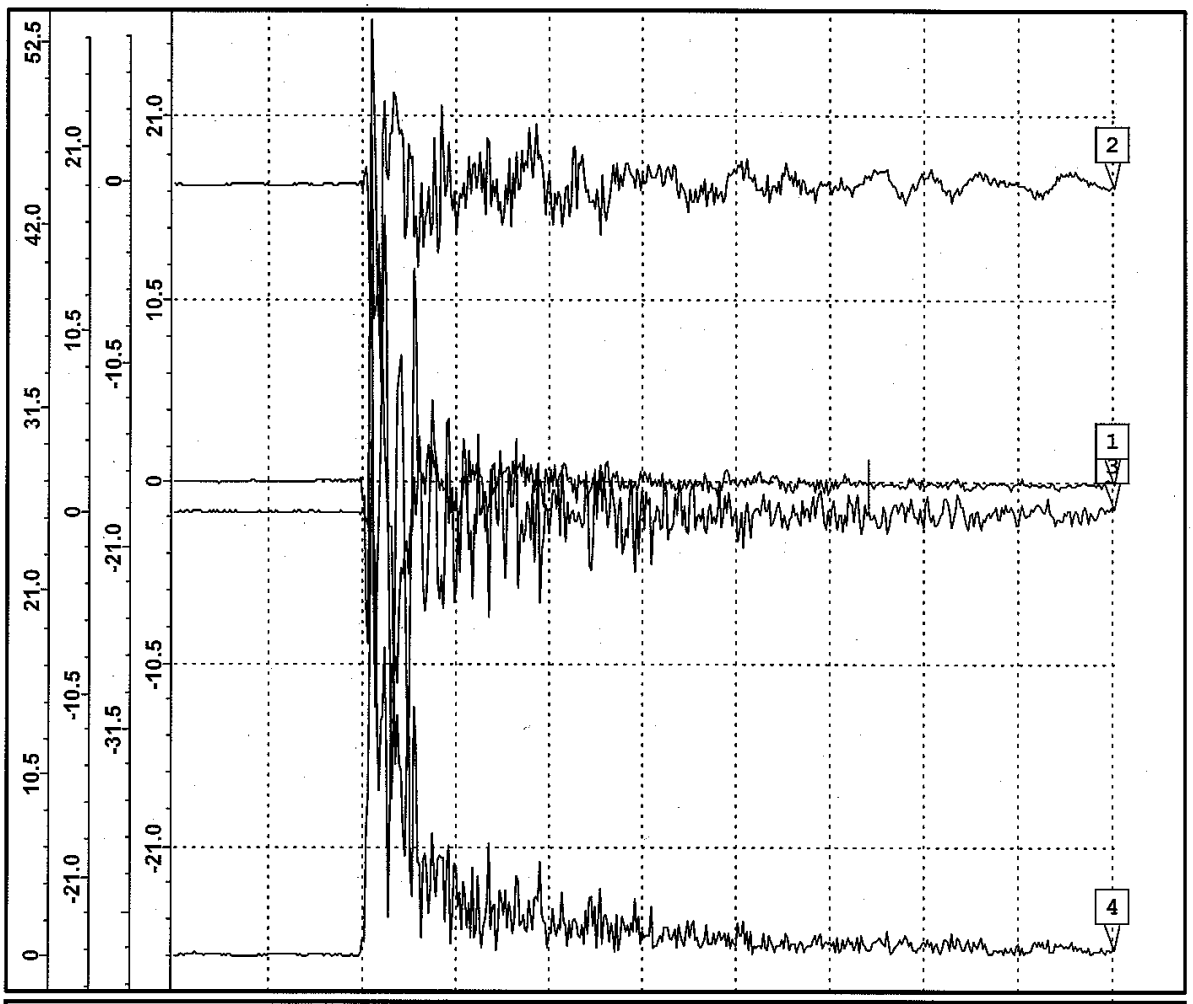
Aft Side = desiccant port side. Ambient temperature and humidity.
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16473.

F22 CANOPY

PENDULUM IMPACT TEST

Time:	**May 24 2007 10:09**	**Test Engineer:**	**Evans**
Test Type:	**Pendulum**	**Impact Point:**	**Aft side**
Container/Item:	**Aluminum/F22 Canopy**	**Impact Velocty:**	**7.3 ft/s**

V. Angle: 106.96;H.Angle: 11.52;



	Ch.	Time		Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
◉	1	967.	mS	-0.13 g's	29.41 g's	22.40 In/s	131 mS	1	2
○	2	967.	mS	0.43 g's	12.13 g's	-50.38 In/s	131 mS	1	2
○	3	967.	mS	0.09 g's	-24.77 g's	27.08 In/s	131 mS	1	2
○	R	967.	mS	0.46 g's	31.66 g's	61.43 In/s	131 mS	1	2

Remarks

Peak Gs X: 29 Y: 12 Z: 25 Peak Gs Resultant: 32

Ch.1=X(fwd-aft); Ch.2=Y(vertical); Ch.3=Z(left-right); Ch.4=Resultant.

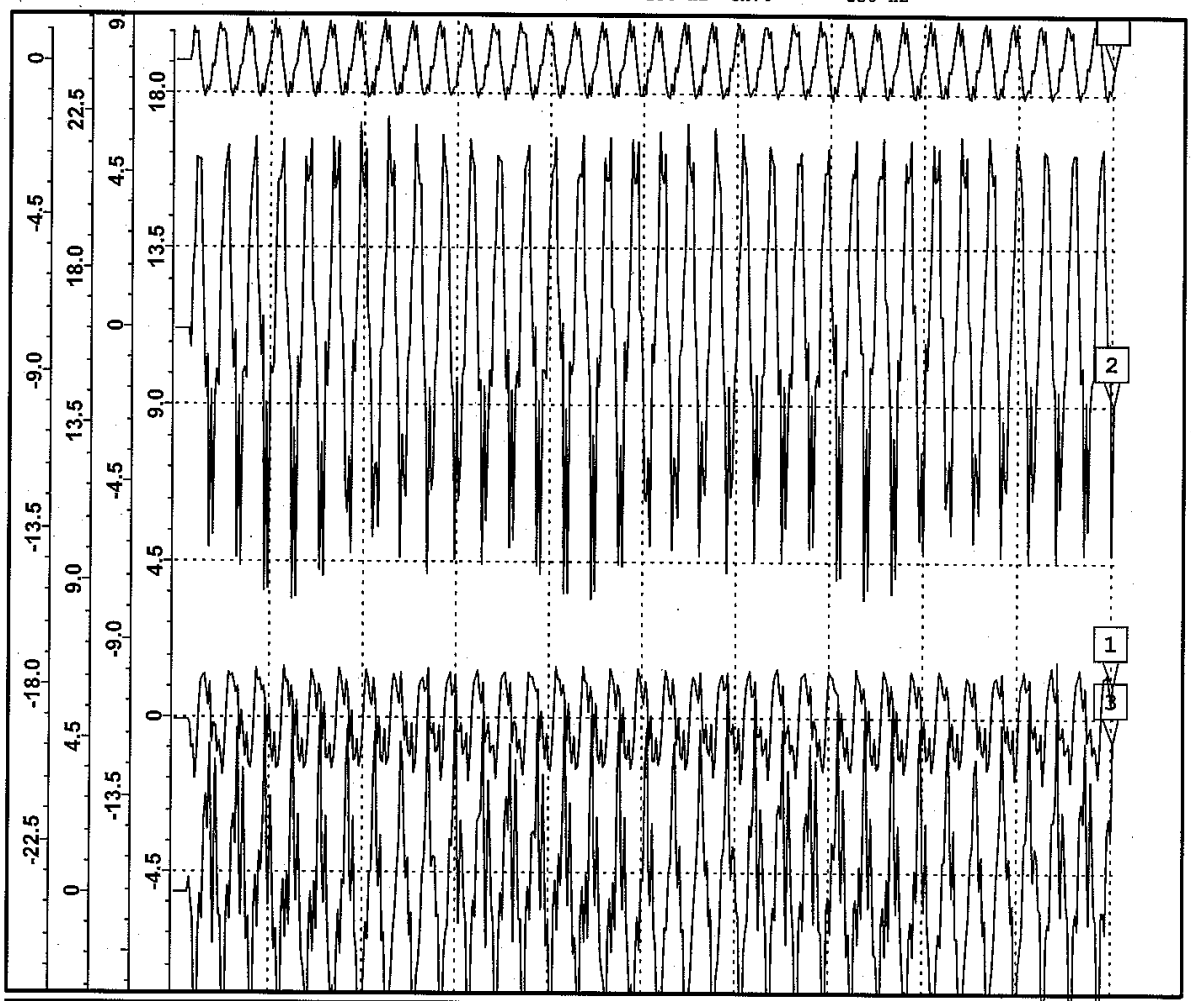
Aft Side = desiccant port side. Ambient temperature and humidity.
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16473.

F22 CANOPY

RESONANCE SWEEP & DWELL

Time:	Jun 6 2007 8:40	Test Engineer:	Evans
Test Stage:	Dwell	Frequency:	13.10 Hz
Test Item:	Aluminum/Canopy HDpl	Time in Test:	3 minutes

Filter: Ch.1 = 150 Hz Ch.2 = 150 Hz Ch.3 = 150 Hz Ch.4 = 150 Hz



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	2.46 S	0.96 g's	-1.93 g's	6.35 In/s	262 mS	1	2
2	2.51 S	2.63 g's	-8.01 g's	44.48 In/s	262 mS	1	2
3	2.47 S	1.55 g's	6.26 g's	-9.42 In/s	262 mS	1	2
4	1.71 S	0.31 g's	1.21 g's	4.42 In/s	262 mS	1	2

Remarks

Transmissibility: 5.7
Peak G X: 2 Gs Y: 8 Gs Z: 6 Gs Table Input(Ch.4): 1 G
RETEST AFTER ADDITION OF DRAW LATCHES and HEAVY-DUTY PLASTIC SUPPORT.

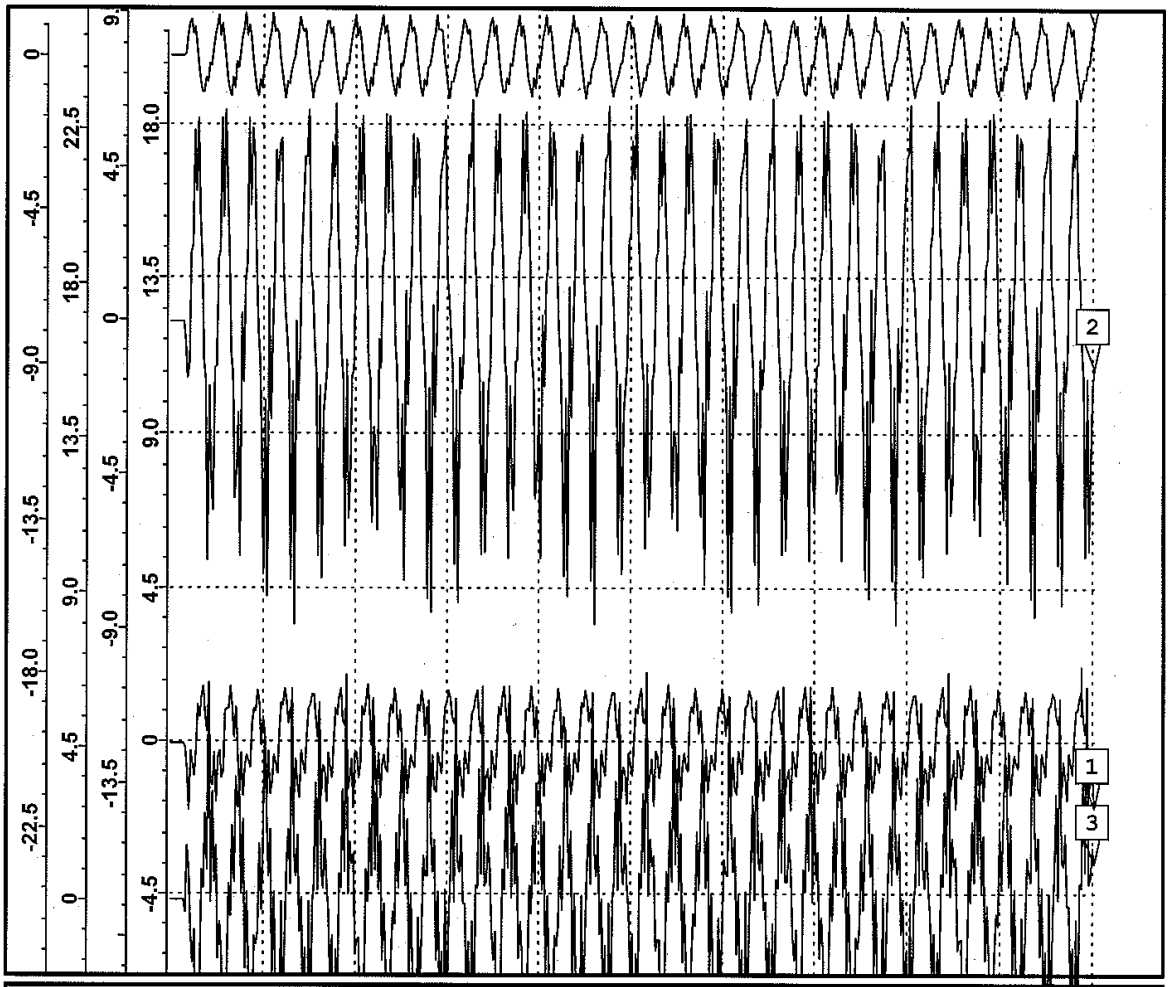
Ch.1=X(forward-aft); Ch.2=Y(vertical); Ch.3=Z(left-right).
Accelerometer: Model 2228C, S/N 16473

F22 CANOPY

RESONANCE SWEEP & DWELL

Time:	Jun 6 2007 8:41	Test Engineer:	Evans
Test Stage:	Dwell	Frequency:	12.85 Hz
Test Item:	Aluminum/Canopy HDpl	Time in Test:	15 Minutes

Filter: Ch.1 = 150 Hz Ch.2 = 150 Hz Ch.3 = 150 Hz Ch.4 = 150 Hz



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	2.58 S	1.50 g's	-1.99 g's	2.35 In/s	262 mS	1	2
2	2.54 S	2.55 g's	-8.98 g's	2.54 In/s	262 mS	1	2
3	2.21 S	6.65 g's	6.80 g's	-3.69 In/s	262 mS	1	2
4	2.48 S	0.07 g's	1.27 g's	11.39 In/s	262 mS	1	2

Remarks

Transmissibility: 5.7
Peak G X: 2 Gs Y: 9 Gs Z: 7 Gs Table Input(Ch.4): 1 G
RETEST AFTER ADDITION OF DRAW LATCHES and HEAVY-DUTY PLASTIC SUPPORT.

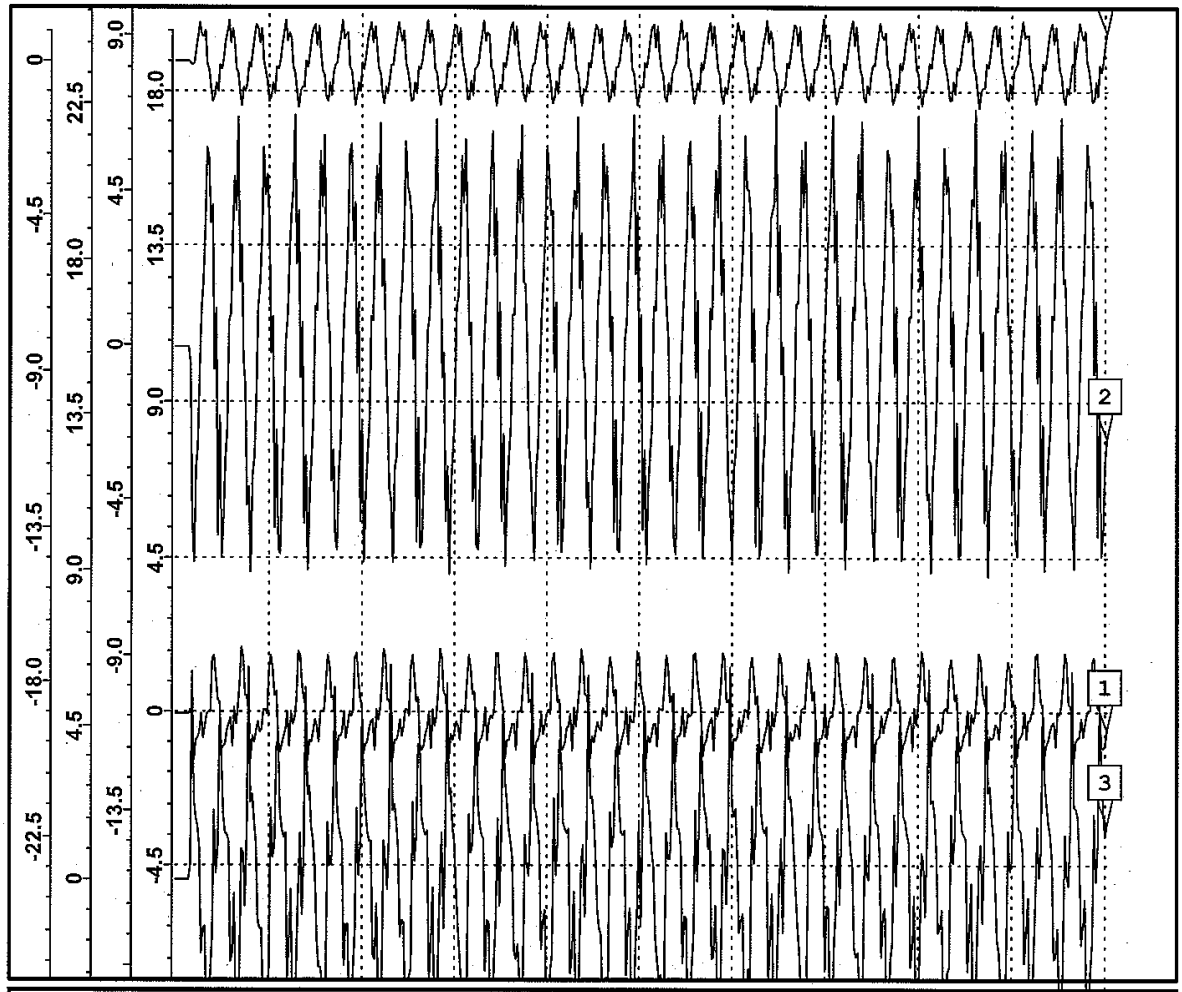
Ch.1=X(forward-aft); Ch.2=Y(vertical); Ch.3=Z(left-right).
Accelerometer: Model 2228C, S/N 16473
ASTM D4169, ASTM D999, SAE ARP 1967

F22 CANOPY

RESONANCE SWEEP & DWELL

Time:	**Jun 6 2007 8:45**	**Test Engineer:**	**Evans**
Test Stage:	**Dwell**	**Frequency:**	**12.55 Hz**
Test Item:	**Aluminum/Canopy HDpl**	**Time in Test:**	**30 minutes**

Filter: Ch.1 = 150 Hz Ch.2 = 150 Hz Ch.3 = 150 Hz Ch.4 = 150 Hz



	Ch.	Time		Curr Amp	Peak Amp	1st Int	Time/Div		Hexp	Vexp
◯	1	2.51	S	0.22 g's	1.92 g's	4.54 In/s	262	mS	1	2
◯	2	2.47	S	0.78 g's	6.99 g's	-25.26 In/s	262	mS	1	2
◯	3	46.08	mS	6.05 g's	6.24 g's	12.86 In/s	262	mS	1	2
◉	4	2.52	S	-0.07 g's	-1.31 g's	-12.86 In/s	262	mS	1	2

Remarks

Transmissibility: 5.3
Peak G X: 2 Gs Y: 7 Gs Z: 6 Gs Table Input(Ch.4):
RETEST AFTER ADDITION OF DRAW LATCHES and HEAVY-DUTY PLASTIC SUPPORT.

Ch.1=X(forward-aft); Ch.2=Y(vertical); Ch.3=Z(left-right).
Accelerometer: Model 2228C, S/N 16473
ASTM D4169, ASTM D999, SAE ARP 1967

APPENDIX 4: Test Instrumentation

PRESSURE TEST EQUIPMENT - Test sequences 1 & 5

EQUIPMENT	MANUFACTURER	MODEL	SN	CAL. DATE
Digital Manometer	Yokogawa	2655	82DJ6001	Mar 07
Digital Manometer	Yokogawa	2655	82DJ6009	Apr 07

ROUGH HANDLING TEST EQUIPMENT - Test sequences 2, 3 & 4

EQUIPMENT	MANUFACTURER	MODEL	SN	CAL. DATE
Shock Amplifier	Endevco	2775A	ER34	NA
Shock Amplifier	Endevco	2775A	ER33	NA
Shock Amplifier	Endevco	2775A	EL81	NA
Item Accelerometer	Endevco	2228C	16473	Sep 06
Data Acquisition	GHI Systems	CAT	Ver. 2.7.1	N/A

APPENDIX 5: Distribution List

DISTRIBUTION LIST

DTIC/O
DEFENSE TECHNICAL INFORMATION CENTER
FORT BELVOIR VA 22060-6218

AFMC LSO/LO
WRIGHT-PATTERSON AFB OH 45433-5540

559 CBSS/GBLA (ATTN JEAN BAXTER)
7701 ARNOLD STREET.
BLDG 1, RM 112
TINKER AFB OK 73145

510 CBSS/GBMAD (ATTN THELMA LOOCK)
7973 UTILITY DRIVE
BLDG 1135
HILL AFB UT 84056

586 CBSS/GBMCAA (ATTN WAYNE OSBORN)
375 PERRY STREET
BLDG 255
ROBINS AFB GA 31098

878 AESG/LG (ATTN FRANK IRWIN)
2725 C STREET
WRIGHT-PATTERSON AFB OH 45433-7424

LOCKHEED-MARTIN AERONAUTICS CO.
(ATTN WILLIAM DARCY)
86 S. CODD DRIVE
MARIETTA GA 30063

APPENDIX 6: Report Documentation

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
27-02-2008	Technical, Final Project Report	August 06 - September 07

4. TITLE AND SUBTITLE
Development of the F-22 Canopy Container

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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susan.evans@us.af.mil, DSN 787-7445, Comm. (937) 257-7445

5d. PROJECT NUMBER
06-P-112

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Packaging Technology and Engineering Facility
AFMC LSO/LOP
5215 THURLOW ST, STE 5, BLDG 70C
WRIGHT-PATTERSON AFB OH 45433-5540

8. PERFORMING ORGANIZATION REPORT NUMBER
08-R-03

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The Air Force Packaging Technology Engineering Facility (AFPTEF) was tasked with the design of a new shipping and storage container for the F-22 Canopy in August of 2006. The new container is designed to replace the wood crate currently used. The current container provides minimal shock protection and no environmental protection against corrosion. Additionally, the wood crate is bulky and very difficult to maneuver. AFPTEF used proven design techniques to meet these design requirements. The CNU-692/E, designed to SAE ARP1967A, is an aluminum, long-life, controlled breathing, reusable shipping and storage container. The new container protects the Canopy mechanically and environmentally. The container passed all qualification tests per ASTM D4169. The CNU-692/E container not only meets user requirements but also provides an economic saving for the Air Force. The savings will be thousands of dollars per Canopy over the twenty-year life span of the container.

15. SUBJECT TERMS
CNU-692/E, F-22 Canopy Container, Aluminum Container, Reusable Container, Design, Test, Long Life

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Joel A. Sullivan
U	U	U	UU	38	19b. TELEPHONE NUMBER *(Include area code)* (937) 257-8162